U.S. Department of Transportation
**Federal Aviation Administration**

# Memorandum

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Subject: **INFORMATION**: Policy for Evaluating Ignitions System Requirements, 14 CFR 33.69

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## 1. Purpose

This policy statement supersedes policy statement number 1998-33.69-R0, dated October 23, 1998, and provides policy and guidance for showing compliance with §33.69 of Title 14 of the Code of Federal Regulations (14 CFR 33.69). The intent of this policy statement is to clarify existing policy regarding §33.69, in order to assist the Aircraft Certification Offices (ACOs) in evaluating applications for aircraft engine type certification. The FAA has revised this policy to address derivative engine models with significant service experience. This policy applies to all classes of turbine powered aircraft engines.

## 2. Definitions

a. Igniter. This device provides a high energy spark to the fuel mixture contained in the engine combustion system. Section 33.69 requires that all engines utilize at least two igniters per engine and two separate secondary electrical circuits; normally each igniter is energized by a separate electrical circuit from the high-tension side of the engine ignition exciter.

b. Ignition Exciter. The exciter is a step-up transformer that contains a low-tension circuit on the primary side and a high-tension circuit on the secondary side. This device steps-up (increases) the supply voltage to the igniters.

c. Ignition System. The ignition system consists of all components of the engine ignition circuit for starting the engine both on the ground and in flight. The components include: wiring leading from the power source (usually the engine mounted alternator or aircraft power bus), the ignition exciter(s), igniter(s) and associated wiring between the exciter(s) and igniter(s), and any other electrical components used as part of the engine ignition circuit.

d. Primary Electric Circuit. The primary circuit is the low-tension side of the engine ignition exciter, including the electrical wiring from the engine electrical power source through the ignition exciter(s)' primary winding.

e. Secondary Electric Circuit. The secondary circuit is the high-tension voltage side of the engine ignition exciter(s), including the electrical wiring from the exciter(s)' output connectors leading down through the igniters.

## 3. Background

The original requirement for turbine engine ignition systems was published in the **Federal Register** on June 20, 1956 (21 FR 119), as part of the Civil Aviation Regulations (CAR), part 13, paragraph 13.211. That regulation required that all turbine engines must be "equipped with an ignition system for starting the engine on the ground and in the air" and did not reference dual redundant systems. The FAA adopted this rule into part 33 (14 CFR part 33) and amended the ignition systems requirement on March 30, 1962. That amendment specified that turbine engines with electric ignition systems: "Shall have at least two igniters and two separate secondary electric circuits." The preamble to that amendment explained that, "This will afford reliability similar to that obtained with reciprocating engines employing dual electric ignition systems." Since all turbine engines have electric ignition systems, this indicates the intent that turbine engines have the same ignition system reliability as reciprocating engines. Section 33.69 was last amended in 1974 to provide an exception to the dual igniter requirement for fuel burning augmentation systems (afterburners).

The FAA has granted only one engine model family an exemption to the dual igniter requirement. In 1962, a manufacturer was granted initial exemption number 219 to CAR part 13.211; this was later extended to similar engine models in that engine family. The exemption was based on the extensive military experience that demonstrated ignition system reliability prior to the original commercial type approval of the same engine. This exemption was reliability-based and is in agreement with the intent of this policy.

## 4. Discussion

Recently, engine and aircraft manufacturers have proposed various interpretations of the requirements of §33.69 to the Engine and Propeller Directorate. There are two common issues in these proposals: the definition of an engine ignition system secondary electrical circuit; and the implied system reliability objective.

a. <u>Two Separate Secondary Electric Circuits</u>. Section 33.69 requires that all turbine engines use two separate "secondary electric circuits." Generally, there are two schools of thought as to the interpretation of this phrase.

(1) One interpretation is that the entire ignition system from the power source down through the igniters must be completely separate and independent. This approach is commonly seen on large turbine engines that have two separate exciter boxes that provide high energy to two independent igniters, assuring high reliability through complete system redundancy and separation. The igniters are the lowest reliability component of the engine ignition system. However, it has been demonstrated fleet-wide through millions of service hours that, when serviced or replaced periodically per the maintenance manual requirements, the igniter component of the ignition system can have a reliability rate at least as high as other components of the system.

(2) An alternate interpretation of the two "separate secondary electric circuits" requirement focuses on the word "secondary." An engine ignition exciter commonly has a primary winding low voltage circuit and a secondary winding high voltage circuit, arranged in a step-up transformer configuration. In this interpretation, only the secondary circuit side of the transformer (high-tension side) down through the igniters is dual and separate. This interpretation could result in a single ignition exciter with dual secondary windings and dual igniters. This approach is commonly seen on small turbine engines,

where a single exciter box is mounted on an engine that has a single primary input to the exciter and dual secondary outputs from the single exciter box that provide high energy to two independent igniters. Although this system could have a less reliable ignition system than the fully redundant system described in paragraph 4.a.(1) of this policy, service experience has not shown a significant shortfall in reliability.

It is predicted that in either case reliability will approach a level of $10^{-6}$ per flight hour and will be probably even more conservative for the fully redundant systems utilizing dual exciters, when appropriately maintained per the manufacturers' instructions. The FAA has determined that either of these interpretations is acceptable to comply with §33.69.

b. System Reliability Objective. Since the original intent of the rule was to "afford reliability similar to that obtained with reciprocating engines," the FAA has made an effort to analyze service history to determine the reliability of reciprocating engine ignition systems. The service difficulty report (SDR) system is the only reporting system that provides failure or reliability data. Unfortunately, this system is incomplete for general aviation reciprocating engines and cannot be considered a reliable source. The original CAR intention of obtaining approximate parity between reciprocating engine and turbine engine ignition system reliability is somewhat incongruous. A loss of a turbine engine ignition system function while in flight is normally a latent failure that does not impact the remainder of the flight. The loss of a reciprocating engine ignition system results in immediate total engine power loss. This suggests that ignition system reliability should be higher for reciprocating engines than for turbine engines. This also reveals the error in the original logic that equated turbine engine and reciprocating engine ignition system reliability, which use completely different design philosophies.

Utilizing the admittedly limited data in the SDR system to examine reciprocating engine ignition system service experience from 1986 through 1996, the FAA estimates that the average reciprocating engine ignition system component failure rate (not necessarily resulting in a shutdown) is about $2 \times 10^{-4}$ per flight hour. The average ignition system failure rate that results in engine shutdowns is estimated to be an order of magnitude smaller, $10^{-5}$ per flight hour, and more reliable. This estimated reciprocating engine ignition system reliability of $10^{-5}$ per flight hour is shown, below, to be lower than the predicted turbine engine ignition system reliability. Due to the significant differences between reciprocating and turbine engine ignition systems, there cannot be direct comparisons between the reliability of the two systems.

The FAA contacted several turbine engine manufacturers to determine the average estimated ignition system failure rate of various models and classes of turbine engines. The data set developed was limited, due in part to a lack of industry response. From this limited data set the FAA has determined that the lowest reliability components of a turbine engine ignition system are often the igniters and the igniter cables; the highest reliability component is normally the exciter. Each of the individual components generally has a failure rate in the range of $10^{-3}$ to $10^{-4}$ per flight hour. This results in a predicted total dual ignition system failure rate in the range of $10^{-6}$ to $10^{-8}$ per flight hour, assuming regular maintenance and regularly scheduled replacement of igniters.

An additional consideration for turbine engine ignition system reliability is the impact of systems reliability on the total engine reliability. Engine manufacturers address this impact during reliability assessment. This assessment should demonstrate that this ignition system reliability does not adversely affect the overall engine reliability. Thus, ignition system reliability should be approximately two orders of magnitude higher (i.e., smaller) than the overall engine reliability. The FAA estimates that typical turbine engine basic power loss reliability is $10^{-4}$ per flight hour. Extended twin engine operations (ETOPS) engine models are more reliable with a power loss reliability target of $10^{-5}$ per flight hour. To avoid an adverse impact on overall engine reliability, a typical turbine engine dual ignition system should have a design reliability of at least $10^{-6}$ to $10^{-7}$ per flight hour; this reliability rate should be considered for new engine models with limited demonstrated overall engine flameout rate. Engines that have significant service experience, such as derivative model certifications, and have demonstrated significantly higher power loss reliability than the assumed average of $10^{-4}$ per flight hour should receive additional consideration (i.e., lower ignition system reliability may be acceptable). This additional consideration is consistent with the original principle of minimizing the hazard of total unrecoverable power loss.

The FAA has granted some engine type certificates based on the premise that the ignition system will be operable in such conditions as surge recovery, bird and ice ingestion recovery, and inclement weather. In these cases, then, the availability of the ignition system may be a basic airworthiness requirement for aircraft dispatch; thus, the ignition system would be subject to frequent functional checks.

**5. General Statement of Policy**

The reciprocating engine ignition system reliability objective is not directly comparable to turbine engine ignition system reliability. Based on research of the CAR, the Civil Aeronautics Manual (CAM), part 33, and an investigation of the configuration of currently certified turbine engine ignition systems, the FAA has determined that §33.69 provides the following:

a. All turbine engine ignition systems must have at least two igniters and two separate secondary electrical circuits. Generally, this requirement can be met utilizing two exciters (i.e., two totally independent ignition circuits). Alternatively, if the reliability goals of paragraph 5.b. of this policy are preserved, two separate circuits from at least the secondary (high tension) side of a single ignition exciter to the two igniters are also acceptable.

b. Engine ignition systems should be designed to achieve a system reliability that results in a system failure rate no greater than $10^{-6}$ per flight hour. Conventional ignition system designs have typically provided this level of reliability. However, more stringent reliability requirements may be warranted under the aircraft requirements in certain circumstances, as defined by the cognizant ACO. This ignition system reliability assessment is an objective and is one method of showing compliance with §33.69, but other methods of meeting the overall engine reliability may be considered. It is reasonable to accept an ignition system failure rate somewhat greater than $10^{-6}$ per flight hour for an engine model that has baseline models with significant service experience that demonstrates acceptably low occurrence rates of engine power loss.

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